

Proper Motions from the Pan-STARRS PS1 Survey

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ABSTRACT

Data from several observations of the PS1 Medium Deep Survey MD09 field have been reduced, and these results have been combined with legacy observations from the U. S. Naval Observatory's Precision Measuring Machine program. These data have allowed for the preliminary determination of the astrometric quality of PS1 observations using stars with known proper motion.

1. DIFFERENTIAL ASTROMETRY FROM PS1

The Pan-STARRS PS1 Survey [1] is approaching routine operational status, and large quantities of image data and catalogs have been produced. The analysis of these data is important for two reasons: they offer the first estimators of the differential astrometric accuracy that the Survey will deliver, and they provide important scientific results through the detection and characterization of stars with large parallaxes (i.e., close to the Sun), or large proper motions.

The number of stars with large parallaxes or proper motions is expected to be substantially smaller than the total number of stars detected by PS1. Hence, it is sufficient to measure the differential motion of the few stars of interest with respect to random field stars, and not perform the more difficult and less accurate measurement of all positions in the system of J2000 (i.e., Right Ascension and Declination). This solution begins with the identification of high quality observation that will be used as the first guess for the positions, and continues with the combination of all measures of all stars through the computation of transformations from each observation to the mean system and the computation of revised values for the star positions and other astrometric quantities. Figure 1 shows the results for a typical solution in the Medium Deep Survey field MD09 (near RA=22:14, Dec=+00:17). The red symbols are from the X (column) solution and the blue from the Y (row) solution. This figure demonstrates that there is a "sweet spot" between magnitudes 18 and 20. Much brighter than 18, the images become saturated and the astrometric quality is degraded by the behavior of the CCD sensor. Much fainter than 20, the astrometric accuracy degrades as the square root of the photon flux. The exposure time for the Medium Deep Survey fields is 250 seconds whereas the exposure time for the 3π Survey is 30 seconds. This difference in exposure time would move the "sweet spot" to between magnitudes 16 and 18 for the 3π Survey. Figure 1 shows an astrometric error of about 15-20 milliarcsec, a value about twice as large as that predicted from studies based on data from other telescopes at other sites. The source of this discrepancy is not yet known, and it may be the case that these early MD09 data are of degraded quality as compared to what will be produced when the PS1 survey enters into routine survey operation.

2. STARS WITH KNOWN PROPER MOTION

The U. S. Naval Observatory ran its Precision Measuring Machine (PMM) program between the years 1994 and 2003. It digitized about 20,000 photographic plates and produced a digital archive of about 13 tera-pixels and about 20 giga-detections. These data were used to compile the USNO-B1.0 and other catalogs. The PS1 MD09 field is particularly well suited for studies based on the photographic archive. The PMM scanned more than 20 plates that cover some or all of the region, and these plates were taken as early as 1950. Hence, the legacy data and the new PS1 data can be combined to produce a catalog of stars with known proper motion in the MD09 field. As the PS1 Survey continues, the value of the photographic data will decrease due to its much lower astrometric quality. Figure 2 shows a star with a relatively large proper motion (about 0.23 arcsec/year) as it appears on two photographic plates and a deep stack computed from four MD09 observations.

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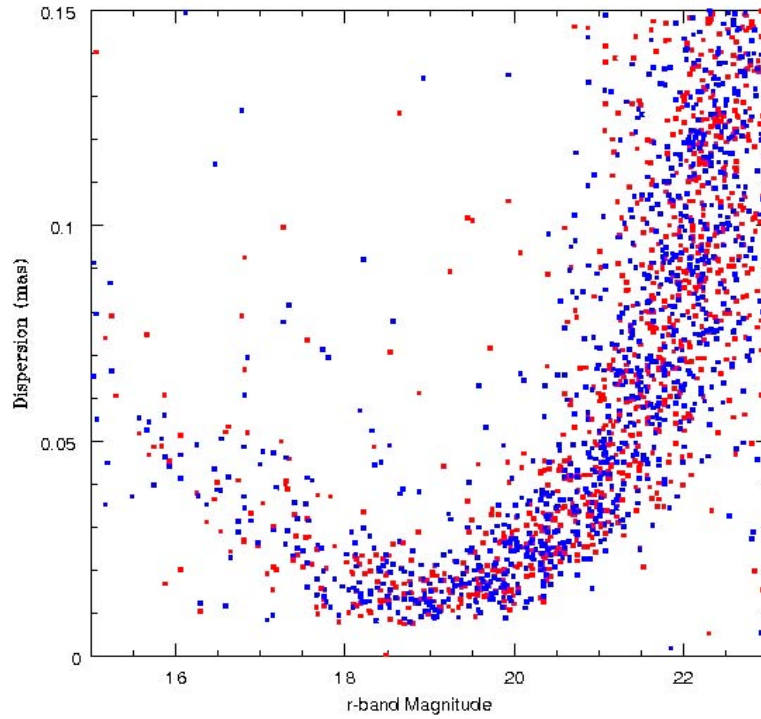


Fig. 1. Astrometric error as a function of r-band magnitude for stars in the MD09 field.

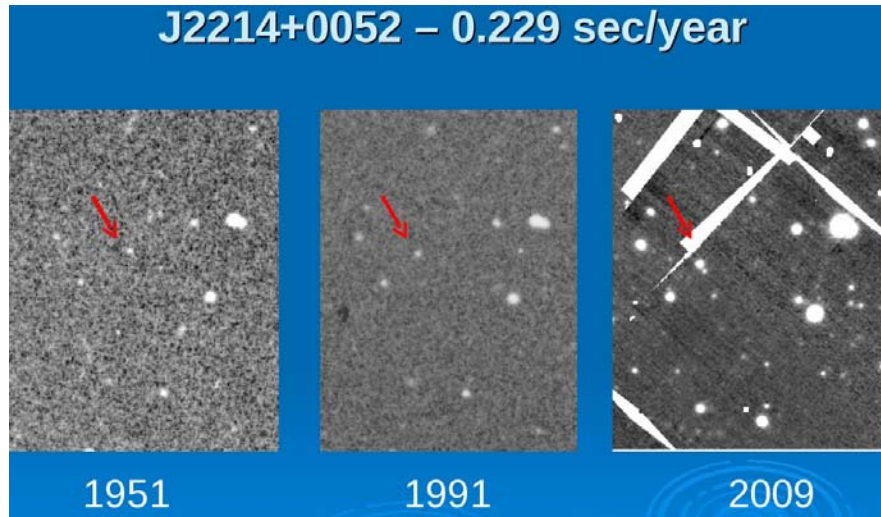


Fig. 2. Images showing proper motion of star J2214+0052 from 1951 to 2009.

3. CONCLUSIONS

Studies of PS1 astrometry are still in their infancy. Analysis of several Medium Deep Survey fields, of which only MD9 is discussed here, shows a differential astrometric accuracy of 15-20 milliarcsec for a single measure of a single, well exposed star. The expectation is that this accuracy will improve as the astrometric pipeline is tuned on the basis of more PS1 data, and as the astrometric performance of the PS1 telescope and camera is characterized. The population of stars with known proper motions is a useful

diagnostic for this type of analysis. Once the first year or two of PS1 data become available, the photographic data can be omitted without loss of accuracy.

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5. REFERENCES

1. Burgett et al., *AMOS Technical Conference (these proceedings)*, 2009.